Haystack Observatory VLBI Correlator

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Abstract

This report summarizes the activities of the Haystack Correlator during 2009. Highlights include an increase in workload, correlation of many broadband delay (VLBI2010) experiments, a digital-backend comparison test, installation of a new data server, IYA2009 preparations, Mark 5 software upgrades, and other software development projects. Non-real-time e-VLBI transfers and engineering support of other correlators continued.

1. Introduction

The Mark IV VLBI correlator of the MIT Haystack Observatory, located in Westford, Massachusetts, is supported by the NASA Space Geodesy Program and the National Science Foundation. The available correlator time is dedicated mainly to the pursuits of the IVS, with a small portion of time allocated to processing radio astronomy observations for the Ultra High Sensitivity VLBI (u-VLBI) project. The Haystack Correlator serves as a development system for testing new correlation modes, for e-VLBI, for hardware improvements such as the Mark 5C system, and for diagnosing correlator problems encountered at Haystack or at one of the identical correlators at the U.S. Naval Observatory and the Max Planck Institute for Radioastronomy. This flexibility is made possible by the presence on-site of the team that designed the correlator hardware and software. Additionally, some production correlator time is dedicated to processing geodetic VLBI observations for the IVS.

2. Summary of Activities

This year has seen a large increase in the workload at the Haystack correlator. Total correlation hours increased >20%, and the total number of experiments processed almost doubled. The broadband delay project in particular saw over a tripling of the number of experiments correlated. The number of 24-hour geodetic sessions (R&Ds and T2s) processed also increased slightly, with several R&Ds requesting rapid turnaround. Astronomy-related projects also saw significant activity, both for the actual correlation and especially for the complex task of setting them up. A 1 mm galactic center (SgrA*) observation project was correlated, and tests of a phased array processing system to combine the collecting area of multiple antennas at the Mauna Kea Hawaii site were an ongoing effort throughout the year. All these projects made for a very busy year. It is anticipated that the processing of the IYA2009 session, which began in December 2009, will contribute to a heavy work load in 2010 as well.

2.1. Broadband Delay Experiments

As mentioned above, many broadband delay development experiments using prototype VLBI2010 systems were conducted and correlated in a wide variety of configurations, including different frequency placements of the RF bands, different LO frequency offsets, and phase cal modifications of various types. These experiments were designed to explore the capabilities and potential limitations of the evolving VLBI2010 hardware. Most were interferometric observations between the

Westford 18-m and the GGAO 5-m antennas, with the post-receiver hardware at each site including four digital back ends (DBEs) and Mark 5B+ units.

These broadband delay experiments dwarfed all but the standard 24-hour geodetic projects this year, both in terms of correlator hours used and in terms of the number of experiments conducted. The early portion of the year was extensively devoted to investigation of phase cal tone corruption and a few polarization studies. Once the phase cal problem was solved, overlapping band tests, frequency offset tests, and source surveys were conducted. Overall, 34 individual broadband schedules were correlated.

2.2. WACO Backup Support

During the Technical Operations Workshop held at Haystack in April, the Haystack correlator was used to process four Kokee-Wettzell Intensive sessions, with the data then being sent down to WACO for export. This was done to demonstrate that Haystack could serve as a backup correlation site in the event of down time at WACO.

2.3. Digital Backend Testing

After the Technical Operations Workshop held at Haystack, a number of attendees stayed to conduct an intercomparison test between independently developed digital backend systems. This so-called "DBE shootout" involved the Chinese DBE system (CDAS), the EVN's dBBC system, and the Haystack-Berkeley designed DBE1. These tests were correlated on the Haystack correlator. For the results of these tests, see: *http://web.haystack.edu/geo/vlbi_td/BBDev/036.html*

2.4. Bonn Correlator Support

Of the requests for help from the Bonn correlator that were fielded this year, the most notable was the diagnosis of a messaging system hang problem which prevented overnight unattended operation of the correlator. This problem was traced back to the disconnecting of all tape drives from the system without the corresponding removal of the mcb program which communicates with them. A work-around, which deletes messages to this process, has fixed the problem until the tape drive communications to mcb can be removed from the software.

2.5. New Server for Disk Space and Post-processing

A new server was procured and is now in use in order to provide 6 TB more disk space for correlator output, more space for software development, and an upgraded post-processing platform. This new capability was especially needed to support the IYA2009 experiment recorded in November.

2.6. Preparations for the IYA2009 Session

Preparations for the IYA2009 were conducted, including fringe tests to check various features needed for the Japanese K5 format stations. These included tests of a data doubling technique to accommodate stations which could not support 8 MHz channel bandwidth, Mark 5B conversion from K5 format, and testing of the IYA2009 recording mode. In a separate but somewhat related project, a Japanese VERA station (Mizusawa) was tested for inclusion in the T2 experiment series.

2.7. Mark 5A/5B/5C Recording System Related Projects

A feature needed in the Mark 5B/DOM correlator playback software (domino) to play back modules with bad individual disks was enabled this year. Conduant's SDK 8.2 software was incorporated into the Mark 5 software in order to address issues with handling SATA modules, and many other Mark 5 support related activities were conducted. SDK 8.2 based Mark 5A software and the Debian operating system were installed on all the Haystack correlator Mark 5A playback units in 2009.

2.8. Correlator Software Development

An upgrade to combine multiple correlator file roots and to fringe-fit up to 64 frequency channels simultaneously in fourfit was a major project this year. This capability is needed for the broadband project and for the 1 mm u-VLBI astronomy projects. Improvements to the correlator software build system to accommodate the growing number of machine architectures and compilers is also a major ongoing project.

2.9. e-VLBI

Non-real-time transfers have continued. Data from 17 experiments were transferred to Haystack this year from six stations, all in Japan: Kashima, Tsukuba, Chichijima, Shintotsukawa, Aira, and Mizusawa.

2.10. Experiments Correlated

In 2009, fifty-seven geodetic VLBI experiments were processed at the Haystack correlator, consisting of ten R&Ds, three T2s, and forty-four test experiments. The test experiments included broadband development and a wide assortment of other projects, some of which were mentioned in the summary above. As usual, there was also a large number of smaller tests that are not included in the above count because they were too small to warrant individual experiment numbers.

2.11. Current/Future Hardware and Capabilities

As of the end of 2009 functioning hardware installed at the correlator included 2 tape units, 7 Mark 5A units, 7 station units, 4 Mark 5B units (DOMs) with their associated correlator interface boards (CIBs), 16 operational correlator boards, 2 crates, and miscellaneous other support hardware. We have the capacity to process all baselines for 11 stations simultaneously in the standard geodetic modes, provided the aggregate recordings match the above hardware matrix. This is the same configuration as described in last year's report.

In 2010, we hope for an expansion of stations recording on Mark 5B units in order to more efficiently process the IYA2009 session that was recorded in November.

3. Staff

Staff who participated in aspects of Mark IV, Mark 5, and e-VLBI development and operations include:

3.1. Software Development Team

- John Ball - Mark 5A/5B; e-VLBI
- Roger Cappallo - real-time correlator software and troubleshooting; system integration; post processing; Mark 5B/5C; Linux conversion; e-VLBI
- Trevor Cappallo - post processing software
- Kevin Dudevoir - correlation; maintenance/support; Mark 5A/5B/5C; e-VLBI; Linux conversion; correlator software and build system development; computer system support/development
- Chester Ruszczyk - e-VLBI; Mark 5A/5B/5C
- Jason SooHoo - e-VLBI; Mark 5A/5B/5C
- Alan Whitney - system architecture; Mark 5A/5B/5C; e-VLBI

3.2. Operations Team

- Peter Bolis - correlator maintenance
- Brian Corey - experiment correlation oversight; station evaluation; technique development
- Dave Fields - playback drive maintenance; Mark 5 installation and maintenance; general technical support
- Glenn Millson - correlator operator
- Arthur Niell - technique development
- Don Sousa - correlator operator; experiment setup; tape library and shipping
- Mike Titus - correlator operations oversight; experiment setup; computer services; software and hardware testing
- Ken Wilson - correlator maintenance; playback drive maintenance; general technical support

4. Conclusion/Outlook

Migration of additional correlator run-time programs to the Linux platform is expected in the coming year. Expansion of the use of Mark 5B units at all correlators will continue in support of IYA2009 processing and as more field stations convert to Mark 5B. More Mark 5C testing is anticipated. Although Mark IV correlator development will continue, a concerted effort to move to a software-based correlator will occur in the coming year. Most likely this will be a variant of the Swinburne correlator originally developed by Adam Deller, similar to the ones at Bonn and the VLBA.